# EVALUATION OF A LOCAL AIR CONDITIONING DUTY CYCLING DEVICE AS A LOAD MANAGEMENT TOOL

KIRK SCHNEIDER
Project Engineer
Dallas Power & Light
Dallas, Texas

MARVIN THEDFORD
Principal Engineer
Texas Power & Light Company
Dallas, Texas

## ABSTRACT

During the summer of 1984, a test was performed to evaluate a local air conditioning duty cycling device as a tool to reduce TUEC's system summer peak demand. In addition to the local duty cycling device, a direct load control device using a power line carrier system was operated, and the results of the two systems were compared. Thirty single family homes in Garland and Richardson were included in the test. The homes' air conditioning compressors were controlled 4 days per week during the test period, using the local and direct control systems on alternate days. Both systems were programmed to cycle the compressor off 30% of the time when operating. The days when no control was performed were used as a base for comparison to the days when the air conditioners were controlled.

The local control device and the direct control device were both found to reduce demand of the compressor by about 0.65 kW at 100°F ambient temperature. Also, the kW reduction achieved was found to increase with higher ambient temperatures. It was also shown that for more oversized units, a higher ambient temperature must be reached in order to achieve the same demand reduction as a properly sized unit. Both control devices were found to cause a minimum amount of discomfort to customers although they raised the temperature in the homes about 2°F during the hottest part of the day. The control did, however, make existing problems with air conditioners, such as improper maintenance and extreme undersizing, more noticeable to the customer, causing them to blame the controls for their discomfort. Finally, the customers were found to look more favorably upon the company as a result of participating in the test project.

## INTRODUCTION

During the summer of 1984, a test was performed to evaluate a local air conditioning duty cycling device as a tool to reduce TUEC's system summer peak demand. In addition to the local duty cycling device, a direct load control device using a power line carrier system was operated, and the results of the two systems were compared. Thirty single family homes in Garland and Richardson were included in the test. The homes' air conditioning compressors were controlled 4 days per week during the test period, using the local and direct control systems on alternate days. Both systems were programmed to cycle the compressor off 30% of the time when operating. The days when no control was performed were used as a base for comparison to the days when the air conditioners were controlled.

## OBJECTIVES

Three objectives were defined for this project. The first objective was to test a local air conditioning duty cycling device to evaluate its potential as a load management tool. The second was to compare the effects of this device with a previously tested power line carrier load control system. The last objective was to determine the customer's attitude toward this type control.

## PROCEDURE

The test was conducted during the months of July through September of 1984. Thirty single family residential customers in Garland and Richardson, Texas, served by Texas Power & Light Company, a division of Texas Utilities Electric Company, were chosen to participate. Most of these customers had previously participated in a direct load control study during the summer of 1983.

The local control device was connected in a series with the thermostat control wire which controls the contactor of the outdoor unit. This electronic device has four possible levels of cycling which may be selected. The device has cycle off times of about 3.5, 4.5, 5.5, and 6.5 minutes off during each 15 minute cycle. In addition, the device is equipped with a time delay of about 2.25 minutes between the time the thermostat calls for cooling and the time the condensing unit comes on. This delay gives the unit additional protection against compressor failure caused by short-cycling. For the test, it was set to have an off time of 4.5 minutes and an on time of 10.25 minutes. This setting allows a maximum reduction of the demand of the condensing unit of 30%.

The direct control device is part of a bi-directional power line carrier load management system. It is a three tier system consisting of a central control computer (CCC), a substation controller (SC), remote transponders and load control receivers (LCR) located on the customer's premises. The CCC communicates over phone lines with the SC which is located at the substation. The SC in turn sends out commands over the power lines to the LCR to shed load or to the transponder to send back load survey, metering, and other data. The software of the system has a limit of 24 duty cycle periods per day. A cycle time of 20 minutes (3 per hour) was chosen and on days when this system was used for load control, the air conditioners were were cycled for 8 hours from 1 to 9 p.m. During the month of July, the off times for each of the hourly off cycles were set at 5, 7.5, and 5 minutes



Proceedings of the Third Symposium on Improving Building Systems in Hot and Humid Climates, Arlington, TX, November 18-19, 1986

for a total of 17.5 minutes off per hour. The load control receivers, however, have a random on-delay built into them to avoid having all air conditioners turn back on simultaneously. This delay is from 0 to 2 minutes long, with an average of 1 minute for each off cycle. Thus the actual off time each hour is about 20.5 minutes off per hour, or a maximum load reduction of 34% of the condensing unit demand. At the end of July, the program was modified to 3, 5 minute off periods which yielded on effective maximum load reduction of 30%, equivalent to the load reduction level set on the local control device.

Load survey data was collected every 15 minutes by the power line carrier system for analysis. Transponders were mounted on a kWh meter to measure air conditioner demand and on a temperature measurement device located in the customer's return air duct to measure the temperature in the house. These data were sent back to the substation controller over the power line which relayed the data over phone lines to the central control computer (CCC). Once a week, the load survey data from the CCC was copied to a tape to be transferred to the Mesquite Data Center for analysis.

A heating and cooling load calculation was performed on each house and the connected kW and EER of each air conditioning unit was determined based on ARI ratings of the equipment. These data are summarized in Table 1. Outside ambient temperature data used in analysis were National Weather Service hourly observations for the Dallas-Ft. Worth Regional Airport.

A load control schedule was set up to operate each load control system on various days of the week. On Wednesdays and weekends, the air conditioners were not controlled, and data from these days were used as a base for comparison with days when the units were controlled. On the remaining days of the week, the direct and local control systems were alternately operated on a daily and weekly basis. Table 2 shows the control schedule used. Since the local controller normally operates 24 hours a day, a 14 day time clock was connected in parallel with the controller to bypass it on "no control" days and when the direct control system was used for load control.

## RESULTS

### SYSTEM RELIABILITY

Reliability of the control system could not be directly measured with the monitoring equipment used; however, in examining the hourly load data obtained from each customer, it was fairly obvious which days the load control units were working properly.

Control devices were also periodically checked in the field to verify that they were working. Load survey data and spot checking verified that all of the local control devices operated during the test period. However, five time clocks that were used to switch control devices failed during the summer, in several cases causing the local controller to operate on incorrect days. Most of the time clock failures occurred near the beginning of the test period, and once they were replaced they operated well for the remainder of the summer. Three of the direct load control devices did not function during the test as shown by the load survey data collected. This fact was verified by spot checks. Due to the unavailability of replacement controllers, however, these units were not replaced. All other direct control devices appeared to operate properly throughout the test. The data collection system failed to collect sufficient usable data on 8 days during the test period. Data was not included in analysis for days when the system was down and for the customers on days when either controller was known to be operating improperly.

### EFFECT OF LOAD CONTROL ON DEMAND AND ENERGY SALES

In order to show the effects of the two types of controllers on a peak day, hourly data for all customers with working controllers were averaged to determine typical load curves. These load curves were developed for weekday data only since air conditioning use is normally different on weekends. For this comparison, all weekdays with a daily maximum temperature of 98 or 99°F were analyzed. This yielded 6 days of data for the local controller, 2 days for the direct control system, and 4 days with "no control". Days with maximum temperatures above 99°F were not included since there was no usable data available for "no control" week days at the higher temperatures. Data for each scenario was analyzed from 6 a.m. to 6 a.m. in order to show the effects of turning off the local controller at midnight, which caused a change that carried over into the following day.

The first six figures show the results of this analysis. Figure 1 shows the hourly average ambient temperature for the days analyzed for the three control scenarios. The average maximum temperature was approximately 98.5°F for each of the groups of days. Ambient temperatures basically track for the three groups of days between 6 a.m. and midnight; however, they are somewhat higher for the "no control" days after midnight. Figure 2 shows the average hourly compressor demand for the three groups of days. The demands on the no control and direct control days are about the same up to 1 p.m., the time at which the direct control system was initiated. A drop in demand is then experienced which continues until 9 p.m., the time at which the control system is released. Following the release of the direct control system, a spike in compressor demand is experienced as the air conditioning system recovers due to heat build up in the structure. On the days when the local controller was used, cycling was performed for 24 hours, from midnight to midnight. It can be seen that from 6 a.m. until about 11 p.m. there is a reduction of demand, and when control is released at midnight, there is a small rise in demand as the air conditioning system recovers. Figure 3 shows the hourly difference in demand created by the two types of controllers as determined from Figure 2. The local control device shows a maximum demand reduction of about 0.5 kW at 6 p.m., and the direct control device shows a maximum demand reduction of 0.5 kW at 7 p.m. The maximum outside temperature was 98-99°F. The direct control device shows a maximum increase in demand at 1 a.m. the following day. Figure 4 shows the demand as measured at the billing meter for the same group of days. Figure 5 shows the average hourly temperature inside the houses for the same group of days. It can be seen that the inside temperature on the direct controls days is about the same as the no control days up until 1 p.m. when control is initiated. At that time, the inside temperature rises slightly to a maximum of about 2°F difference at 9 p.m. After 9 p.m., when the direct control is released, the inside temperature begins to come back down to the same level as on no control days. Using the local controller, the inside temperature is increased by about 1°F in the morning and increases to a difference of about 2°F at 8 p.m. When control is released at midnight, the temperature begins to drop back down to no control levels. The hourly temperature change is shown in Figure 6.

In order to determine the varying effect of a particular load control scenario with ambient conditions, compressor demand was correlated with ambient temperature. Data used for this correlation consisted of all houses with working control devices. Average compressor kW was calculated for each ambient temperature during the test period. Ideally, the data used would be for weekdays only since air conditioner usage is typically different on weekends; however, no data was available for temperatures above 98°F on "no control" weekdays, so that data from the weekends was used as a estimate for temperatures above 98°F for "no control" days. Figure 7 shows the average compressor kW plotted versus ambient temperature, for each of the three control scenarios. There is no significant effect of controlling the air conditioners by duty cycling until the outdoor ambient temperature is above 90°F. At 100°F ambient temperature, the demand reduction was approximately 0.65 kW for both control systems. No data was available for the local control system when the temperature was above 100°F; however, the direct control system showed reductions of about 0.8 kW at 103°F. Figure 8 shows the change in compressor demand for the two control systems compared with no control, as a function of ambient temperature.

Because each control scenario was not used the same number of days and the cooling requirements vary from day to day, kWh usage for the three different scenarios could not be measured directly. An estimate was made based on assuming each load control scenario was run every weekday for the entire test period. This estimate was made by first calculating the average compressor kW for each hour at a given ambient temperature (data from Figure 7) and then multiplying that average kW by the number of hours during the test period (July 1-September 25) at that temperature. It was assumed that there was zero demand by the compressor when the outside temperature was below 68°F. Both control scenarios were estimated to reduce total compressor kWh by an average of about 8 to 9% on the days when the units were controlled. The reduction of kWh as measured at the billing meter was estimated to be about 6% for the direct control system and about 4% for the local control system on the days when the units were controlled.

Data was also analyzed to isolate the effects of load control on the three groups of houses based on structural efficiency and air conditioner sizing. The group of standard efficiency homes with properly sized equipment were an average of 2% oversized, the energy efficient structures with properly sized units were an average of 0% oversized, and the energy efficient structures with oversized units were an average of 33% oversized. Figure 9 shows the relationship between compressor demand and outside temperature for each of the three groups on "no control" days only. The measured demands for the three groups are approximately the same up to about 98°F. At that temperature, demand for the energy efficient structures with proper sized equipment begins to level off. The demands in the energy efficient homes with oversized units and in the standard efficiency homes with properly sized equipment keep rising. The average installed compressor kW of the standard proper size group was 5.1 kW; however, the average demand was only about 4 kW at 106°F. The average installed compressor kW for the energy efficient properly sized group was 3.2 kW. The demand for this group was shown to level off at about 1.9 kW. For the energy efficient, over sized group, the average installed compressor kW was 4.9, and it only reached a demand of about 3.9 kW at 105°F. Figures 10 - 12 show the daily load curves for each of the three groups for the same days analyzed previously (all days with maximum temperature of 98 or 99°F. The greatest demand reduction was experienced in the energy efficient homes with properly sized units (Figure 11). The least demand reduction was obtained in the energy efficient homes with over sized units (Figure 12), and the standard efficiency homes with properly sized units showed a demand reduction between the other two groups (Figure 10).

## CUSTOMER REACTIONS AND PROBLEMS

Feedback from the customers participating in the program was in general very favorable and positive. This is reflected in the fact that only three of the 30 participants in the program chose not to participate the following year. One of these three dropped out of the program because he was very uncomfortable on days when his unit was controlled. This customer also had the most undersized unit of the group (see table 1, customer #30, 29% undersized), and had several other problems with air distribution as well. The customer asked that the controllers be removed from his house after only a week of controlling. The second chose not to participate the following summer because he felt that the controller might damage his air conditioner. This customer had replaced his air conditioner during the spring of 1984. The third customer chose not to participate the following summer because he was moving.

In the post test survey, seven customers reported that they were uncomfortable on some of the days when control was performed, in addition to the one customer who dropped from the program. Two of these complained frequently that they were uncomfortable; however, these problems could be traced to improper charging of the air conditioning system and poor maintenance of the unit. One of these customers had a new air conditioner installed near the end of the summer and did not experience any discomfort after that time. The remaining five said that they were slightly uncomfortable on one or two days during the summer when their unit was controlled but did not think it was a real problem. Only one participant reported being less comfortable in their home compared with the previous summer, and this customer said that it was because he was setting the thermostat higher to save money. Two customers said that they made some changes in their activities as a result of the program. Five participants said that they found something objectionable about the program, including four who mentioned being occasionally uncomfortable and one who felt that the control might damage the air conditioner. One customer also said he did not like the fact that he had no control over the system. About two-thirds of the participants reported that they set their thermostats between 78 and 80°F; however, the remaining customers set them as low as 68°F and as high as 85°F. Also, about two-thirds of the customers reported that they varied the setting of their thermostat.

Since there was a concern among some of the participants that duty cycling might damage their air conditioner, a strategy of providing air conditioner maintenance in lieu of a cash rebate might reduce a load control program's cost as well as alleviate the concerns of the customer. For this reason, customers were asked whether they would be interested in a utility sponsored air conditioner maintenance program. All but two said they would be interested in such a program, and nineteen felt it should be a service for the load control program. This type of service might also provide the utility with an opportunity to inspect and repair load control equipment on a regular basis.

Almost all felt that they had benefitted as a result of participating in the project because of the incentive paid them, but many also said that they felt satisfaction in helping the utility and the energy situation, and because of the educational value of participating. Nearly all of the customers reported that their attitude toward TP&L was more favorable as a result of participating, mainly because they believed that the company is trying to help keep down their future electric bills.

## ANALYSIS OF RESULTS

The demand reductions achieved by the two types of control systems were approximately the same, which would be expected since they were both programmed to achieve the same percent cycle off time. Compressor demand was reduced by an average of about 0.5 kW at 98 - 99°F outside temperature and about 0.65 kW at 100°F outside temperature. The average installed compressor kW was about 3.9 kW. For 30% duty cycling, the maximum attainable compressor demand should be about 2.7 kW (70% of 3.9 kW) or a maximum possible demand reduction of 1.2 kW. At 100°F, both control systems showed an average demand of about 2.6 kW which is slightly below that which was expected. For the direct control system, it can be observed that there was no increase in compressor demand above 100°F. Although no data was available above 100°F for the local control system, its demand should also level out above 100°F. As the outside temperature increases above 100°F, demand reductions attained increase rapidly. For the direct control system, a demand reduction of 0.8 kW was attained at 102°F. These results are similar to those obtained in the direct load control testing done during the summer of 1983. Results of this study can be found in the report entitled "Rockwell Load Control Project, Phase II, Feasibility of Direct Residential A/C Control", dated January, 1986. In this previous study, a slightly smaller demand reduction was found (about 0.6 kW at 100°F outside temperature). However, the typical house in the 1983 study had a slightly more over sized air conditioner than in the 1984 study (12% vs. 10%), which may explain this difference.

It was found that both control systems reduced electrical energy used by the compressor by about 9%, the direct control reduced the kWh measured at the billing meter by about 6%, and the local control reduced the kWh measured at the billing meter by about 4%. The smaller kWh reduction of the local controller may be explained by the fact that it was operated 24 hours whereas the direct controller was operated for only 8 hours. Since the local controller was run 24 hours, it was operating at lower temperatures for more hours than the direct control. The extra kWh for the local controller was probably a result of an increased run time for the air handler at lower outside temperatures; however, air handler demand was not directly measured. Although this would decrease the demand reduction at lower temperatures, it would not be as important a factor at higher temperatures when the air handler would normally run for a higher percentage of time. If the controllers had been operated on every weekday of the summer, the kWh reductions would have been approximately 6% for the compressor and about 3-4% for the billing meter. These kWh reductions are substantially higher than those estimated in the previous summer of testing. In the 1983 load control testing, it was found that compressor kWh were reduced by about 3% and billing kWh by about 2% on days when the compressors were cycled 30%. This difference is due to the fact that 1983 was a much cooler than average summer, whereas 1984 was a fairly typical summer. Therefore, the kWh reductions observed in this study are probably more representative of what would be typically obtained. In general, the more days the unit is controlled and the hotter those days are, the greater the overall reduction in kWh usage will be.

As shown in Figure 9, the energy efficient homes with properly sized equipment show no increase in compressor demand above 100°F under normal conditions (no control), since the units reach a condition of 100% run time at this point. At the point where the unit reaches 100% run time under no control conditions, the maximum demand reductions may be achieved, equal to the percentage cycle off time multiplied by the connected kW. Therefore, for an energy efficient structure with a properly sized unit, the maximum demand reduction may be achieved at outside temperatures as low as 100°F. On the other hand, the energy efficient homes with over sized units continue to have an increasing compressor demand above 100°F under no control conditions. Thus cycling below 100°F will have little effect on demand since the units, which are an average of 30% over sized, will already be cycling off 30% of the time at design conditions. The standard efficiency structures with properly sized units showed less demand reduction than the efficient structures with properly sized units. This may be explained by the fact that the standard structures had slightly more oversized units (2% vs. 0%) and the fact that the temperatures inside the standard efficiency structures were set at an average of about 2°F higher, which tends to cause more natural diversity.

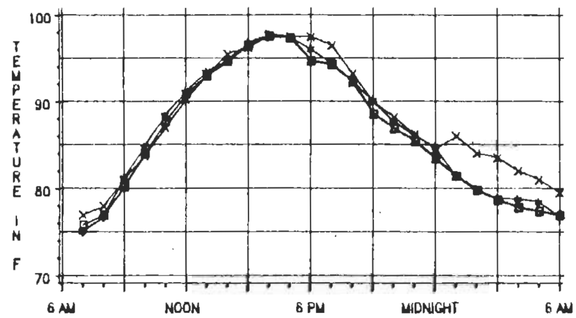
All of the serious customer complaints about being uncomfortable when their air conditioners were being controlled could be traced back to problems with the installation or maintenance of the system. Aside from these problems, none of the participants were affected by the controlling to the point that they did not want to continue participating in the program. Furthermore, the program had the effect of improving the customer's image of the utility by showing them that the company is trying to do something to help them. Thus it can be concluded that this type of program can be acceptable for most customers.

The on peak demand reductions which can be obtained by duty cycling residential air conditioners using direct load control or using local load control are basically the same. Direct load control, however, has the advantage that control is only exercised by the utility when it is needed. Thus the customer's comfort will not be affected as often. Also, direct load control may be used in an emergency situation to turn the air conditioner completely off. In addition to the flexibility in controlling customer's loads, a two-way direct load control system has additional benefits such as the possibility of remote meter reading and distribution automation. However, a local controller would cost much less than a direct control system if air conditioning control was the only desired function. Furthermore, the capability might be built into the local controller to allow it, for example, to operate only on weekdays, during the utility's peak hours to minimize any inconvenience to the customer.

## CONCLUSIONS

A local air conditioning duty cycling device may be used as an effective means of reducing a utility's summer system peak demands. Reductions of about 0.65 kW were obtained, cycling the compressor off for 30% of the time, at design conditions (100°F ambient temperature), and these reductions should be greater at higher ambient temperatures. The effect of the controller was also found to be a function of the oversizing of the air conditioning. For an oversized unit, off cycles must be longer or ambient temperatures must be higher to achieve the same demand reductions. The effect of the load control device on peak demand was found to be the same as the effect of a direct control device. There are advantages to each system which must be weighed before deciding which is more appropriate. Further, the local control device was found to cause a minimum amount of discomfort to customers although it did raise temperatures in the homes about 2°F during the hottest part of the day. The control did however make existing problems with air conditioners more noticeable to the customer, causing them to blame the controller for their discomfort. Finally, customers were found to look more favorably upon the utility as a result of participating in this test project.

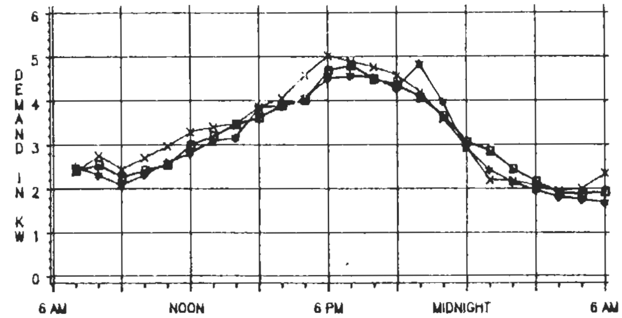
AVERAGE AMBIENT TEMPERATURE VS. HOUR
FOR WEEKDAYS WITH MAXIMUM TEMPERATURE OF 98 OR 99 F




CONTROL NO CONTROL DIRECT CONTROL LOCAL CONTROL

FIGURE 1

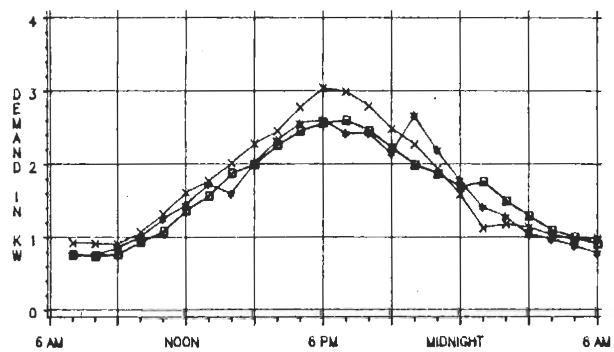
AVERAGE BILLING DEMAND VS. HOUR
FOR WEEKDAYS WITH MAXIMUM TEMPERATURE OF 98 OR 99 F




CONTROL NO CONTROL DIRECT CONTROL LOCAL CONTROL

FIGURE 4

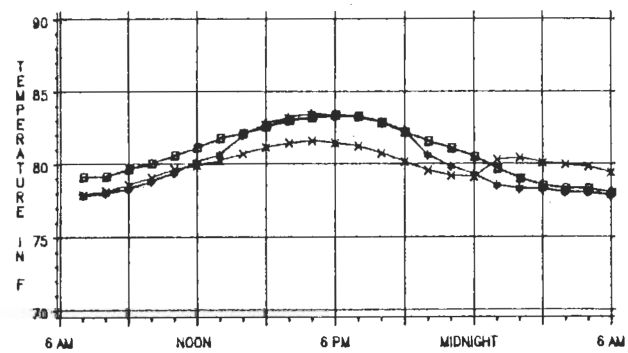
AVERAGE COMPRESSOR DEMAND VS. HOUR
FOR WEEKDAYS WITH MAXIMUM TEMPERATURE OF 98 OR 99 F




CONTROL NO CONTROL DIRECT CONTROL LOCAL CONTROL

FIGURE 2

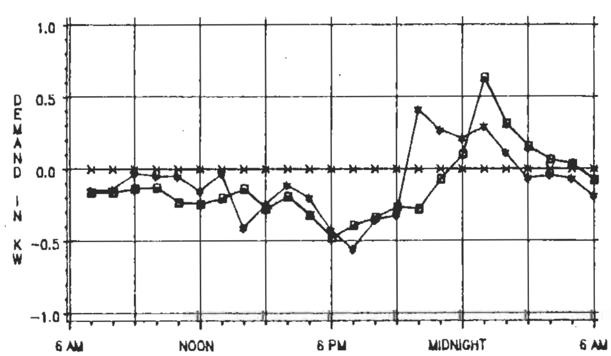
AVERAGE INSIDE TEMPERATURE VS. HOUR
FOR WEEKDAYS WITH MAXIMUM TEMPERATURE OF 98 OR 99 F




CONTROL NO CONTROL DIRECT CONTROL LOCAL CONTROL

FIGURE 5

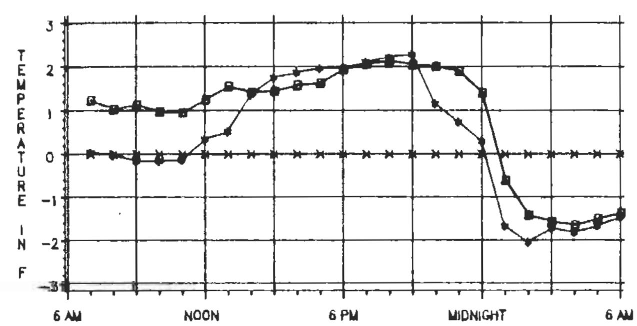
CHANGE IN COMPRESSOR DEMAND VS. HOUR
BETWEEN NO CONTROL AND CONTROL DAYS




CONTROL NO CONTROL DIRECT CONTROL LOCAL CONTROL

FIGURE 3

CHANGE IN INSIDE TEMPERATURE VS. HOUR
BETWEEN NO CONTROL AND CONTROL DAYS




CONTROL NO CONTROL DIRECT CONTROL LOCAL CONTROL

FIGURE 6

AVERAGE COMPRESSOR DEMAND VS. AMBIENT TEMPERATURE

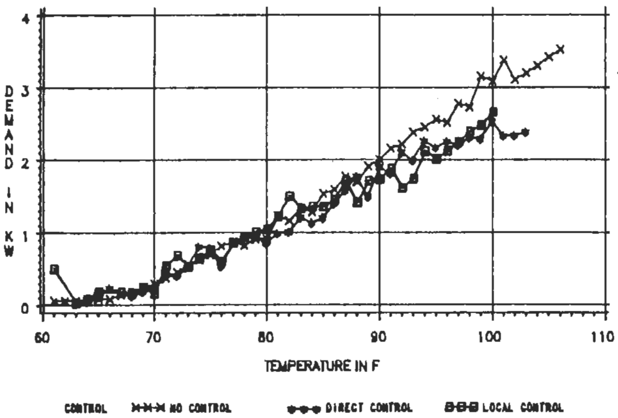



FIGURE 7

CHANGE IN COMPRESSOR DEMAND VS. AMBIENT TEMPERATURE
BETWEEN NO CONTROL AND CONTROL DAYS

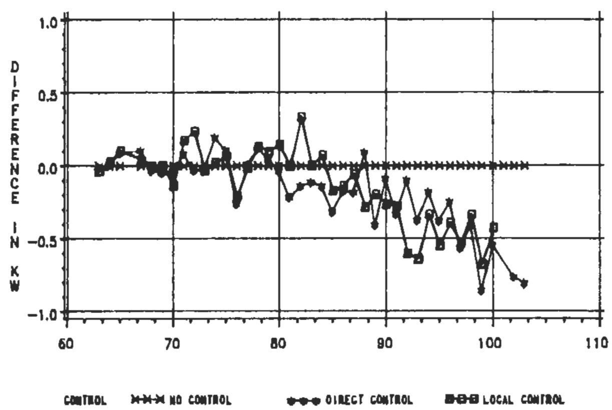



FIGURE 8

AVERAGE COMPRESSOR DEMAND VS. AMBIENT TEMPERATURE
BY STRUCTURE AND EQUIPMENT GROUP
FOR NO CONTROL DAYS

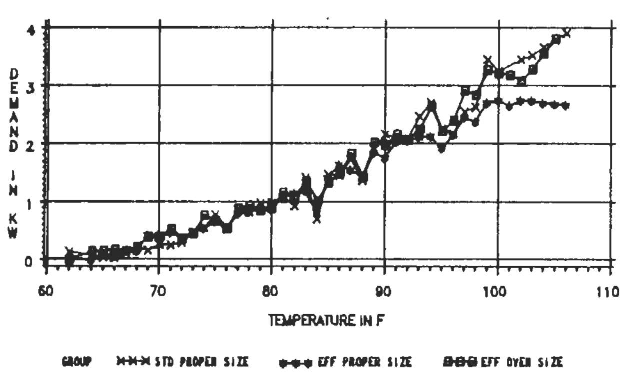



FIGURE 9

AVERAGE COMPRESSOR DEMAND VS. HOUR
FOR WEEKDAYS WITH MAXIMUM TEMPERATURE OF 98 OR 99 F
GROUP=STANDARD - PROPERLY SIZED

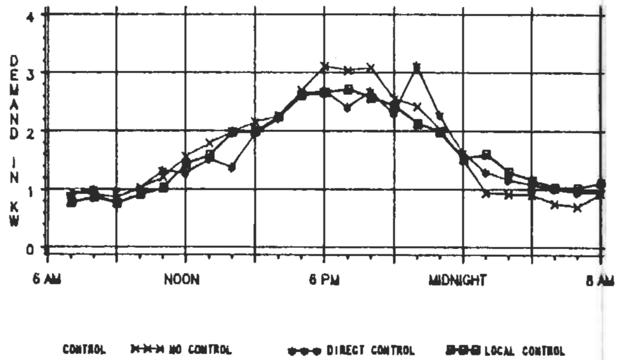



FIGURE 10

AVERAGE COMPRESSOR DEMAND VS. HOUR
FOR WEEKDAYS WITH MAXIMUM TEMPERATURE OF 98 OR 99 F
GROUP=EFFICIENT - PROPERLY SIZED

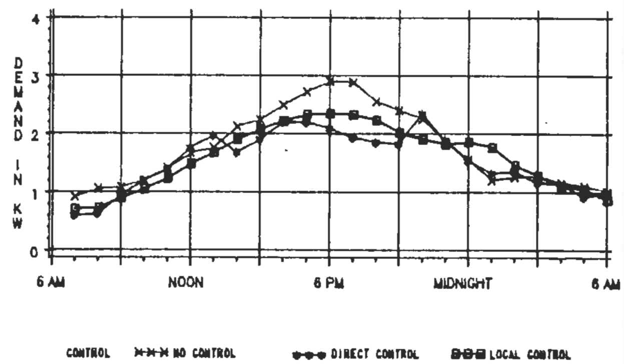



FIGURE 11

AVERAGE COMPRESSOR DEMAND VS. HOUR
FOR WEEKDAYS WITH MAXIMUM TEMPERATURE OF 98 OR 99 F
GROUP=EFFICIENT - OVER SIZED

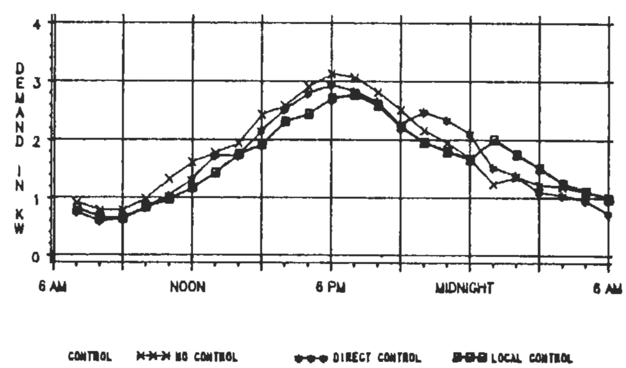



FIGURE 12

AIR CONDITIONING EQUIPMENT AND STRUCTURE DATA
Group A - Properly sized equipment, non energy efficient home
Group B - Properly sized equipment, energy efficient home
Group C - Oversized eqyuonebtm energy efficient home

| ID # | Group | Sq.Ft. Space | Req'd. Tons | Inst. Tons | EER | % Over-sized | Sq.Ft. Per Ton | Design kW |
|---|---|---|---|---|---|---|---|---|
| 1 | B | 2532 | 3.2 | 3.3 | 7.8 | 3% | 791 | 4.9 |
| 2 | C | 2298 | 3.6 | 4.4 | 8.5 | 22% | 638 | 5.1 |
| 3 | C | 2287 | 2.8 | 3.5 | 9.0 | 25% | 817 | 3.7 |
| 4 | A | 1684 | 3.2 | 2.9 | 6.6 | -9% | 526 | 5.8 |
| 5 | C | 1800 | 2.2 | 3.8 | 9.9 | 73% | 818 | 2.9 |
| 6 | C | 1612 | 2.5 | 3.4 | 8.3 | 36% | 645 | 3.6 |
| 7 | A | 2142 | 3.8 | 4.0 | 10.0 | 5% | 564 | 4.6 |
| 8 | A | 2104 | 3.9 | 3.8 | 7.1 | -3% | 539 | 6.6 |
| 9 | B | 1784 | 2.9 | 2.9 | 11.4 | 0% | 615 | 3.1 |
| 10 | A | 1590 | 2.9 | 2.9 | 6.5 | 0% | 548 | 5.4 |
| 11 | C | 1898 | 2.8 | 3.7 | 6.5 | 32% | 678 | 5.2 |
| 12 | B | 1498 | 2.5 | 2.9 | 6.5 | 16% | 599 | 4.6 |
| 13 | C | 1963 | 2.2 | 2.9 | 7.0 | 32% | 892 | 3.8 |
| 14 | C | 1806 | 2.9 | 3.5 | 6.7 | 21% | 623 | 5.2 |
| 15 | A | 1976 | 3.8 | 4.0 | 7.3 | 5% | 520 | 6.2 |
| 16 | A | 1379 | 3.3 | 3.5 | 6.7 | 6% | 418 | 5.9 |
| 17 | B | 1368 | 2.1 | 2.3 | 6.5 | 10% | 651 | 3.9 |
| 18 | B | 1880 | 2.1 | 2.0 | 8.7 | -5% | 895 | 2.9 |
| 19 | C | 1457 | 2.2 | 2.8 | 6.3 | 27% | 662 | 4.2 |
| 20 | B | 1426 | 2.3 | 2.3 | 6.8 | 0% | 620 | 4.1 |
| 21 | A | 1607 | 3.2 | 3.3 | 6.2 | 3% | 502 | 6.2 |
| 22 | B | 1578 | 2.0 | 2.0 | 7.0 | 0% | 789 | 3.4 |
| 23 | B | 1290 | 2.1 | 1.0 | 7.0 | -5% | 614 | 3.6 |
| 24 | C | 1455 | 1.9 | 2.4 | 7.6 | 26% | 766 | 3.0 |
| 25 | B | 1439 | 2.4 | 2.5 | 6.7 | 4% | 600 | 4.3 |
| 26 | A | 1334 | 2.4 | 2.5 | 7.5 | 4% | 556 | 3.8 |
| 27 | B | 1954 | 2.5 | 2.0 | 7.0 | -20% | 782 | 4.3 |
| 28 | C | 1838 | 2.3 | 3.0 | 7.1 | 30% | 799 | 3.9 |
| 29 | B | 2135 | 3.2 | 3.0 | 7.1 | -6% | 667 | 5.4 |
| 30 | A | 1550 | 2.8 | 2.0 | 7.0 | -29% | 554 | 4.8 |
| Averages - | | 1755 | 2.7 | 3.0 | 7.4 | 10% | 656 | 4.5 |

Table 1

1984 Air Conditioning Control Schedule

| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|---|
| 7/1 - 7/7 | NO CONTROL | DIRECT | LOCAL | NO CONTROL | DIRECT | LOCAL | NO CONTROL |
| 7/8 - 7/14 | NO CONTROL | LOCAL | DIRECT | NO CONTROL | LOCAL | DIRECT | NO CONTROL |
| 7/15 - 7/21 | NO CONTROL | DIRECT | LOCAL | NO CONTROL | DIRECT | LOCAL | NO CONTROL |
| 7/22 - 7/28 | NO CONTROL | LOCAL | DIRECT | NO CONTROL | LOCAL | DIRECT | NO CONTROL |
| 7/29 - 8/4 | NO CONTROL | DIRECT | LOCAL | NO CONTROL | DIRECT | LOCAL | NO CONTROL |
| 8/5 - 8/11 | NO CONTROL | LOCAL | DIRECT | NO CONTROL | LOCAL | DIRECT | NO CONTROL |
| 8/12 - 8/18 | NO CONTROL | DIRECT | LOCAL | NO CONTROL | DIRECT | LOCAL | NO CONTROL |
| 8/19 - 8/25 | NO CONTROL | LOCAL | DIRECT | NO CONTROL | LOCAL | DIRECT | NO CONTROL |
| 8/26 - 9/1 | NO CONTROL | DIRECT | LOCAL | NO CONTROL | DIRECT | LOCAL | NO CONTROL |
| 9/2 - 9/8 | NO CONTROL | LOCAL | DIRECT | NO CONTROL | LOCAL | DIRECT | NO CONTROL |
| 9/9 - 9/15 | NO CONTROL | DIRECT | LOCAL | NO CONTROL | DIRECT | LOCAL | NO CONTROL |
| 9/16 - 9/22 | NO CONTROL | LOCAL | DIRECT | NO CONTROL | LOCAL | DIRECT | NO CONTROL |
| 9/23 - 9/29 | NO CONTROL | DIRECT | LOCAL | NO CONTROL | DIRECT | LOCAL | NO CONTROL |

Table 2